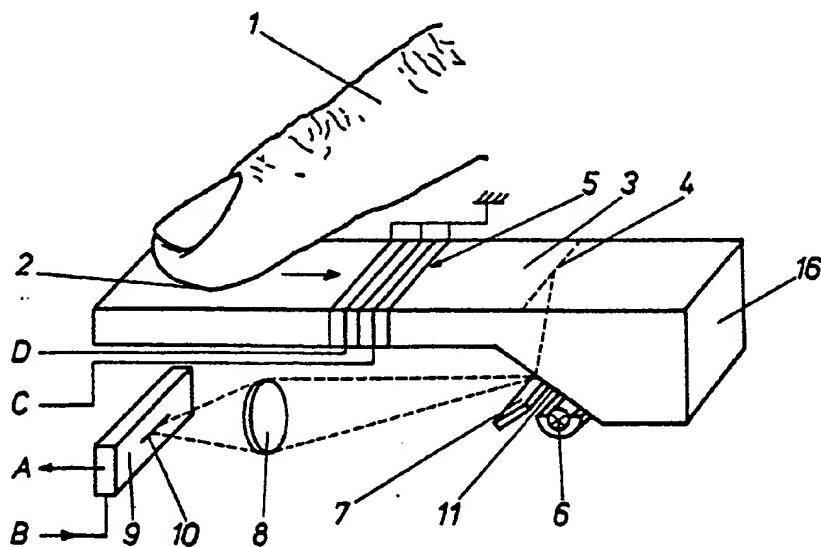




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

|  |    |   |
|--|----|---|
| (51) International Patent Classification <sup>4</sup> :<br><br>A61B 5/10   | A1 | (11) International Publication Number: WO 86/ 06266<br><br>(43) International Publication Date: 6 November 1986 (06.11.86)  |
| (21) International Application Number: PCT/DK86/00044  |    | (81) Designated States: AT, AT (European patent), AU, BE (European patent), BG, BR, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CM (OAPI patent), DE, DE (Auxiliary utility model), DE (European patent), DK, FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL, NL (European patent), NO, RO, SD, SE, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US. |
| (22) International Filing Date: 28 April 1986 (28.04.86)   |    |   |
| (31) Priority Application Number: 1984/85  |    |   |
| (32) Priority Date: 2 May 1985 (02.05.85)  |    |   |
| (33) Priority Country: DK  |    |   |
| (71) Applicant (for all designated States except US): JYDSK TELEFON A/S [DK/DK]; Sletvej 30, DK-8310 Århus (DK).           |    | Published<br>With international search report.<br>In English translation (filed in Danish).   |
| (72) Inventor; and   |    |   |
| (75) Inventor/Applicant (for US only) : JENSEN, Palle, Rasmus [DK/DK]; Forhåbningsholms Allé 30, DK-1904 København V (DK). |    |   |
| (74) Agent: LARSEN & BIRKEHOLM A/S SKANDINAVISK PATENTBUREAU ; Niels Hemmingsens Gade 32, DK-1153 København K (DK).        |    |   |

(54) Title: METHOD AND APPARATUS FOR AUTOMATIC SCANNING OF FINGERPRINTS



(57) Abstract

An apparatus for automatic scanning of a fingerprint by optical scanning of the fingerprint side (2) of a finger (1) comprises a scanning surface (3) with a measuring means (5) for the rate of movement of the finger in relation to the scanning surface, and with a scanning area (4), a lighting means (6), an optical system (7, 8) and an electrical/optical scanning means (9) giving an electrical signal (A) as a function of the fingerprint when the finger is moved in contact with the scanning surface (3) in the direction of the arrow. The scanning is undertaken by line scanning along the scanning line (4) in that the scanning line is imaged onto the active part of the scanning means (9). The active part consists for example of a number of substantially punctiform photodiodes (10) which are coupled in the electrical circuit and receives control signals (B) so that the photodiodes are scanned successively.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

|                                 |   |                             |
|---------------------------------|---|-----------------------------|
| AT Austria                      | GA Gabon                                    | MR Mauritania               |
| AU Australia                    | GB United Kingdom                           | MW Malawi                   |
| BB Barbados                     | HU Hungary                                  | NL Netherlands              |
| BE Belgium                      | IT Italy                                    | NO Norway                   |
| BG Bulgaria                     | JP Japan                                    | RO Romania                  |
| BR Brazil                       | KP Democratic People's Republic<br>of Korea | SD Sudan                    |
| CF Central African Republic     | KR Republic of Korea                        | SE Sweden                   |
| CG Congo                        | LI Liechtenstein                            | SN Senegal                  |
| CH Switzerland                  | LK Sri Lanka                                | SU Soviet Union             |
| CM Cameroon                     | LU Luxembourg                               | TD Chad                     |
| DE Germany, Federal Republic of | MC Monaco                                   | TG Togo                     |
| DK Denmark                      | MG Madagascar                               | US United States of America |
| FI Finland                      | ML Mali                                     |                             |

1      METHOD AND APPARATUS FOR AUTOMATIC SCANNING OF  
FINGERPRINTS.

5      The invention relates to a method of the kind described in the introduction to claim 1 and to an apparatus for carrying out same as described in the introduction to claim 6.

10     There are known various methods for optical scanning of the fingerprint side of a finger for ascertaining the identity of a person or for identifying the characteristic papillary pattern of a finger. The scanning may take place manually and the papillary pattern may be characterised by means of one of the known systems whereof some are digital so that the pattern characteristics may be machine processed as soon as the characterisation has been completed. Manual scanning, however, is highly time-consuming

15     because a fingerprint readily comprises 25 characteristic details whereof at least 6-10 details will often have to be characterised in order to achieve positive identification.

20     There has therefore been developed various apparatuses for optical scanning of the fingerprint side of a finger. These apparatuses have a movable optical means which scans the fingerprint side. Mechanically movable means are difficult to design

25     so that they will not take up too much space and such apparatuses moreover require regular maintenance.

The object of the invention is to provide a method

- 1 and an apparatus for optical/electrical scanning  
of the fingerprint side of a finger without using  
any mechanically movable means so that there is  
obtained an apparatus which will not require  
5 maintenance. It is moreover an object to provide  
an apparatus which is rather small so that it can  
be built into existing apparatuses such as telephone  
apparatus, entrance control apparatus and the like.
- 10 This object is achieved by proceeding as further  
disclosed in the characterising part of claim 1,  
for example by using an apparatus as further  
disclosed in the characterising part of claim 6.  
In stead of mechanically scanning the fingerprint  
15 side, it is according to the invention the finger  
which is moved during an optical/electrical scanning  
where simultaneously with or immediately before  
the scanning the rate of movement of the finger  
is measured. The mechanical movements in the known  
20 apparatuses have thereby been transferred into  
a modest finger movement where in stead of placing  
the finger on or in a scanning means, the finger  
is slid on a scanning surface, whereby the  
fingerprint side is scanned and there is obtained  
25 an electrical signal representing the fingerprint  
which signal can be processed in the usual manner  
in electrical apparatuses for example for  
comparaison with stored information.
- 30 By proceeding as disclosed in the characterising  
part of claim 2, a simple way of performing the  
scanning is achieved. It is sufficient to make  
the scanning surface transparent at the place of  
scanning. The points along the scanning line where

1       the finger touches the surface (the ridges of the  
fingerprint) will reflect the light differently  
from the points where the finger does not touch  
the surface. By scanning the passing finger line  
5       by line there is obtained a complete scanning of  
the fingerprint.

By proceeding as disclosed in the characterising  
part of claim 3 there is achieved increased  
10      certainty of identification or recognition in that  
the use of copied prints of fingers or the use  
of a false finger such as a plastic or rubber cast  
is thereby excluded. By proceeding as disclosed  
in claim 3 it is simply checked whether it is a true  
15      finger or not.

An improved scanning is obtained by proceeding  
as disclosed in the characterising part of claim  
4. There is moreover obtained increased safety  
20      against undue entering or wrong identification.  
By a uniform friction between the finger and the  
scanning surface it is possible in a simple manner  
electrically to synchronise or scale the line  
scanning with the rate of movement which will be  
25      sufficiently constant during the scanning. The  
rate measuring is thus used for synchronising or  
scaling the scanning.

30      By measuring the skin resistance as disclosed in  
the characterising part of claim 5 there is obtained  
a sufficiently accurate measuring to determine  
whether it is a genuine finger or not.

The apparatus according to the invention may be

1     designed as disclosed in the characterising part  
      of claim 7. It is sufficient to make the scanning  
      area transparent by the scanning line. If, for  
      example, a scanning surface made of plastics, for  
5     example glass or synthetic materials such as acrylic  
      plastics is used, the entire surface except the  
      scanning area itself may be coated by a black  
      coating such as black paint or the like so that  
      undesirable light or undesirable reflections are  
10    avoided. There is thus obtained an apparatus that  
      is insensitive to changes in light strength etc.  
      in the surroundings where the apparatus has been  
      mounted.

15    The apparatus may practically be designed as  
      disclosed in the characterising part of claim 8.  
      There is thus obtained a simple apparatus where  
      the purely physical design may be changed in many  
      different ways, for example dependent on where  
20    the apparatus is to be used or mounted.

25    The functioning of the apparatus and certainty  
      of correct measuring are further increased by  
      designing the apparatus as disclosed in the  
      characterising part of claim 9; this will not,  
      however, substantially increase the complexity  
      or power consumption of the apparatus.

30    The measuring means in the apparatus is according  
      to the invention preferably designed as disclosed  
      in the characterising part of claim 10. The result  
      is inter alia that the apparatus can be divided  
      in two parts, one part where the scanning is done,  
      and another part, the electrical part, from where

1 the scanning is monitored and controlled. The two parts may without any practical problems be placed apart.

5 It is obvious that a method and an apparatus according to the invention may be used for many different purposes, but has preferably been developped for use in connection with entrance control as further disclosed in claim 11.

10

The invention will be further explained in the following with reference to the drawing showing an embodiment of the invention wherein

15

Fig. 1 shows the scanning system itself, and

Fig. 2 shows the electrical circuit therefor.

20

In the drawing reference numeral 1 is a finger, the fingerprint side 2 of which is to be scanned. The finger is moved in contact with a scanning surface 3 on a part 16 of an apparatus which part may for example be a moulded acrylic block or a similar transparent material. In the scanning surface 3 there is arranged a measuring means 5 for skin resistance and finger rate of movement and there is moreover shown a scanning area 4 in the form of a scanning line. The scanning surface 3 with the measuring means 5 is designed so as to give all over the surface a substantially uniform friction against the finger movement so that without problems it is possible to move the finger at the same constant rate across the measuring means 5

25

30

1 and the scanning line 4. The measuring means 5  
consists for example of five mutually separated  
measuring wires made of electrically conducting  
material embedded in the surface. The centre wire  
5 and the two outer wires are connected to each other  
and are used as reference, for example frame  
connected, whereas the two remaining wires C and  
D are connected to the measuring circuit shown  
in Fig. 2. The rate of the finger is measured by  
10 registering the points of time  $T_C$  and  $T_D$  where  
the finger 1 loses contact with the second and  
the fourth wire, respectively, in the direction  
of movement.

15 In the shown and explained example the measuring  
means 5 has five measuring wires. It is obvious  
that it is possible to use some other number of  
measuring wires - the entire surface 3 may if so  
desired be covered by measuring wires - dependent  
20 on the measuring method etc.

Under the apparatus part 16 there is arranged an  
elongate lighting means 6, for example an elongate  
lamp, a dense row of light diodes or some other  
25 form of elongate light source. The lighting means  
6 is placed perpendicularly to the direction of  
movement of the finger and is provided with a  
reflector or a slit-shaped shutter so that  
substantially all light is directed towards the  
30 scanning area 4. The lighting means 6 may be mounted  
next to the apparatus part 16 as shown in Fig.  
1, but may also be mounted inside the apparatus  
part 16, for example in a cylindrical cross bore.

1 Next to a light pass surface 11 there is provided  
a mirror 7, for example a surface mirror throwing  
reflected light from the entire scanning area 4  
onto the active part 10 of an optical/electrical  
5 scanning means 9 which part 10 is for example a  
linear photoarray with for example 256 punctiform  
photocells. The line 4 is imaged onto the linear  
photoarray 10 by means of an optical system that  
may comprise one or more lenses 8. The  
10 optical/electrical means 9 receives control signals  
through a wire B in such a manner that only one  
photocell at a time will give an electrical signal  
through the wire A representing the light intensity  
by which the cell is influenced. Through wire A  
15 there is thus obtained an electrical analog signal  
representing reflected light from the line 4, i.e.  
a line scanning of the contact print against the  
scanning surface 3 of the print side 2 of the  
finger.

20

The rate of movement of the finger 1 measured with  
the measuring means 5 is used for synchronising  
or scaling the scanning.

25

In order to avoid false reflections and to be  
capable of using as weak a lighting means 6 as  
possible, the entire apparatus part 16 has been  
painted dull black, except on the scanning area  
4 and on the light pass surface 11.

30

By adjusting the mirror 7 it is possible to move  
the scanning area 4, for example in such a manner  
that it is placed quite close to the rate measuring  
means 5. If desired, the scanning line 4 may be

1 placed between two of the measuring wires, for example between the two last wires in the direction of movement of the finger.

5 Fig. 2 of the drawing shows a schematic block diagram of the electrical circuit. At the left top the scanning surface 3 with the measuring means 5 and the two measuring wires C and D are shown. A 10 kHz square voltage may for example be applied  
10 to the wires C and D so that noise and mains hum problems are avoided. The wires C and D are connected to each its bridge circuit and the finger contact is detected when the bridge is brought off balance when the finger touches the wire. The  
15 points of time  $T_C$  and  $T_D$  are measured when the finger leaves the respective wire and the time difference is used as an expression of the rate of movement of the finger. At the same time the circuit 12 measures the skin resistance twice i.e.  
20 between wires C and D and the other three connected wires, respectively. The result of the measurement of the skin impedance or the skin resistance and the measured points of time  $T_C$  and  $T_D$  is directed to a control and converter circuit 14 which also  
25 contains the power supply to the various circuits and the lighting means 6.

The scanning means 9 is via an amplifier 13 connected to the control and converter circuit  
30 14 which inter alia by means of the impulses received from a clock generator undertakes the required controlling, signal processing and digitalisation of the measurement results from the photo array 10 and sends the digital measurement

1 results to a binary store 15 such as a 256 x 256  
x 1 bit store which may exactly hold one complete  
fingerprint. It is obvious to a person skilled  
in the art that other sizes and forms of store  
5 circuits may be used. From the store 15 the  
digitalised fingerprint may be transmitted for  
data processing together with any required  
synchronisation signal.

10 The data processing itself of the stored fingerprint  
does not form part of the invention and will  
therefore not be further described.

15 It is obvious to a person skilled in the art that  
the electrical circuit shown in Fig. 2 may be  
designed and built up in a great number of different  
ways and that the circuit may moreover be  
constructed by using generally known circuits while  
obtaining the desired function.

20

25

30

1

## PATENT CLAIMS

1. Method for automatic scanning of fingerprints by optical scanning of the fingerprint side of  
5 a finger, characterised in that the finger is moved along a scanning surface while measuring the rate of movement in relation to the scanning surface and in such a manner that by contact between finger and surface there is formed  
10 an optical papillary pattern corresponding to a fingerprint whereupon the pattern is scanned when passing a scanning area and is converted into an electrical signal.

15 2. Method according to claim 1, characterised in that the scanning surface is transparent in the scanning area and the passing papillary pattern is being scanned line by line perpendicularly to the direction of  
20 movement.

25 3. Method according to claim 1 or 2, characterised in that the skin resistance of the finger is measured substantially at the same time while measuring the rate of movement.

30 4. Method according to claim 3, characterised in that the entire scanning surface is designed so as to give substantially the same friction against the finger and that the skin resistance and the rate of movement are measured immediately before or simultaneously with the scanning of the fingerprint

1 and that there is formed no electrical signal corresponding to the finger print if the skin resistance and/or the rate of movement lie(s) outside pre-determined ranges.

5

5. Method according to claim 3 or 4, characterised in that the skin resistance is measured by at least one impedance measuring by using alternating current.

10

6. Apparatus for automatic scanning of fingerprints according to claim 1 by optical scanning of the fingerprint side of a finger, characterised in comprising a scanning surface (3) with a measuring means (5) for the rate of movement of the finger in relation to the scanning surface and with a scanning area (4) incorporating a lighting means (6), an optical system (7, 8) and an electrical/optical scanning means (9) giving an electrical signal (A) as a function of the fingerprint.

15

7. Apparatus according to claim 6, characterised in that the scanning surface (3) is transparent in the scanning area being a rectilinear area (4) transverse to the direction of movement of the finger and being adapted to line by line scanning of the fingerprint as the finger passes the area in that the scanning surface is designed in such a manner that it has substantially uniform surface friction on the entire surface.

20

8. Apparatus according to claim 6 or 7,

1       c h a r a c t e r i s e d    in that the lighting  
means (6) is an elongate light source provided,  
if desired, with reflector or slit-shaped shutter,  
that the optical system comprises focusing means  
5       (8), and if desired, deflector means (7) so that  
the scanning area (4) is imaged onto the active  
part of the electrical/optical scanning means (9)  
which part consists of an array of substantially  
punctiform photodiodes (10) connected in an  
electrical circuit which is supplied with control  
10      signals (B) in such a manner that the photodiodes  
are scanned successively.

9.       Apparatus according to claim 6,  
15      c h a r a c t e r i s e d    in that the measuring  
means (5) is furthermore provided with conductor  
means (C, D) for measuring the skin resistance  
of the fingerprint side (2).

20      10. Apparatus according to claim 6 or 9,  
c h a r a c t e r i s e d    in that the measuring  
means (5) consists of a number of electrical  
conductors placed apart and arranged transverse  
to the direction of movement in the surface of  
25      the scanning area (3) where between some of the  
conductors there is applied an alternating voltage  
for determining the impedance of the skin and a  
voltage for determining the rate of movement of  
the finger in that the points of time are scanned  
30      when the finger loses electrical contact with the  
conductors and the time difference is used for  
determining the rate of movement.

11. Use of an apparatus according to any one of

13

1 claims 6 to 10 for entrance control to premises  
or for operating apparatus.

5

10

15

20

25

30

1/2

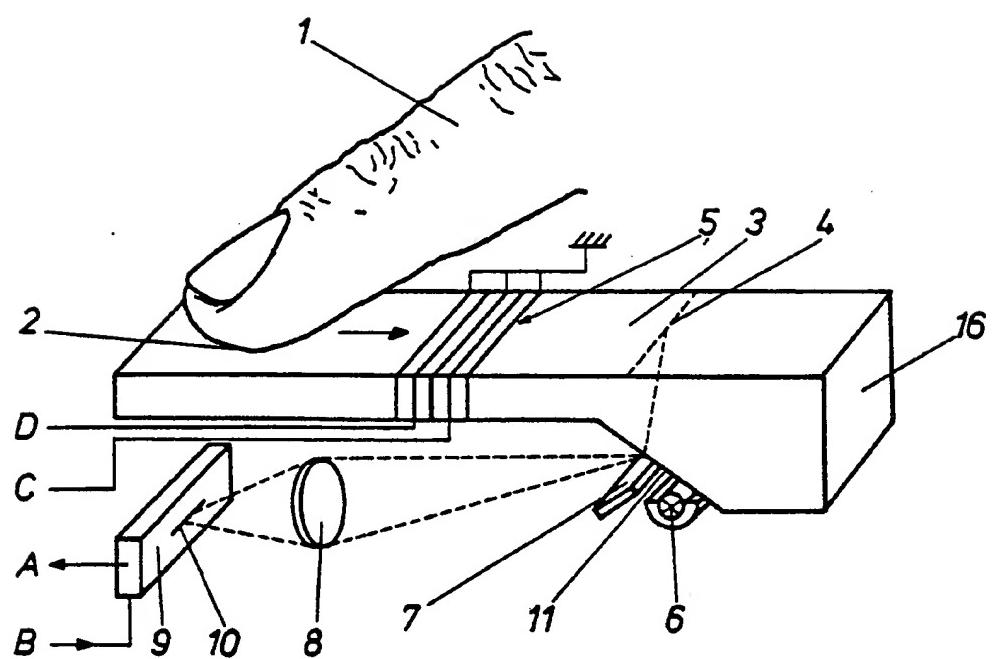


Fig. 1

2/2

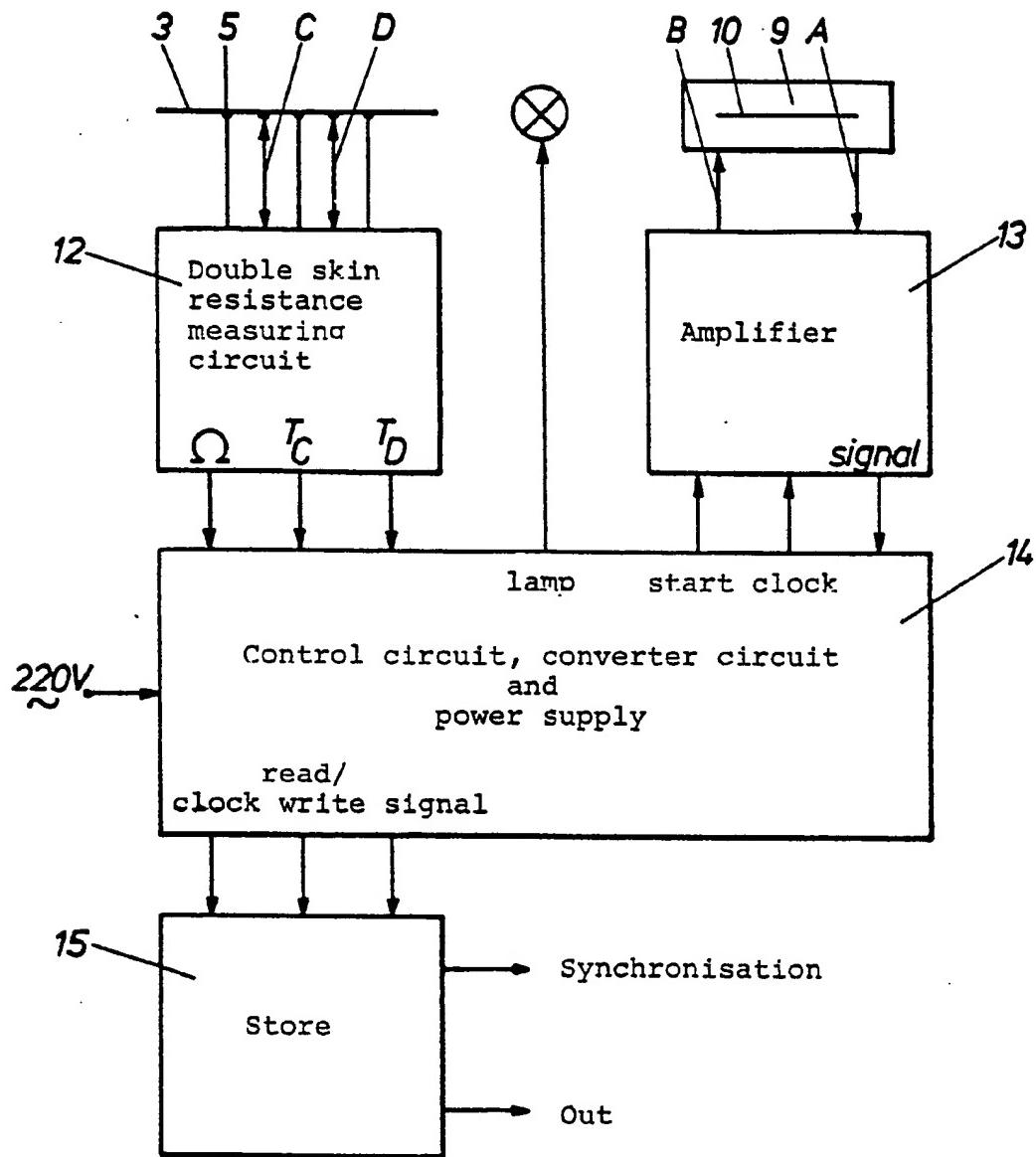


Fig. 2

# INTERNATIONAL SEARCH REPORT

International Application No. PCT/DK86/00044

## I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) \*

According to International Patent Classification (IPC) or to both National Classification and IPC 4

A 61 B 5/10

## II. FIELDS SEARCHED

Minimum Documentation Searched ?

| Classification System | Classification Symbols  |
|-----------------------|---|
| IPC 4<br>US CL        | A 61 B 5/05 /10; G 01 P 3/42, /64, /66<br><u>118</u> :31.5; <u>356</u> :71; <u>427</u> :1 |

Documentation Searched other than Minimum Documentation  
to the Extent that such Documents are Included in the Fields Searched \*

SE, NO, DK, FI classes as above

## III. DOCUMENTS CONSIDERED TO BE RELEVANT \*

| Category * | Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup> | Relevant to Claim No. <sup>13</sup> |
|------------|--|-------------------------------------|
| A          | US, A, 4 322 163 (MICHAEL SCHILLER)<br>30 March 1982   | 1, 2, 6, 7,<br>8, 10                |
| A          | DE, A1, 2 056 472 (OMRON TATEISI ELECTRONICS<br>CO.)<br>3 June 1971  | 3, 4, 5, 9,<br>10                   |
| A          | EP, A1, 0 045 913 (SIEMENS AKTIENGESELLSCHAFT)<br>17 February 1982   | 8                                   |
| A          | SE, B, 321 110 (EBAUCHES SA)<br>23 February 1970   | 1, 3, 6, 10                         |

\* Special categories of cited documents: <sup>10</sup>

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"Z" document member of the same patent family

## IV. CERTIFICATION

Date of the Actual Completion of the International Search

1986-07-30

Date of Mailing of this International Search Report

31 JUL 1986 ( 31.07.86 ) ▲

International Searching Authority

Swedish Patent Office

Signature of Authorized Officer

Gunnar Hilderoth

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V.  OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE<sup>1</sup>

This International search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1.  Claim numbers ..... because they relate to subject matter not required to be searched by this Authority, namely:

2.  Claim numbers ....., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.  Claim numbers ....., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI.  OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING<sup>2</sup>

This International Searching Authority found multiple inventions in this International application as follows:

- 1) Claims 1, 2, 6, 7, 8, 10: Optical scanning of fingerprints.
- 2) Claims 3, 4, 5, 9, 10: Measurement of skin impedance.

1.  As all required additional search fees were timely paid by the applicant, this International search report covers all searchable claims of the International application.

2.  As only some of the required additional search fees were timely paid by the applicant, this International search report covers only those claims of the International application for which fees were paid, specifically claims:

3.  No required additional search fees were timely paid by the applicant. Consequently, this International search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4.  As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

- The additional search fees were accompanied by applicant's protest.  
 No protest accompanied the payment of additional search fees.